LA-UR-21-28352
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Title: MARSAME Release Report for TA-03 Building 16

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Intended for: Report

Issued: 2021-08-20

MARSAME Release Report for TA-03 Building 16
August, 2021

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08/10/2021 LA-UR-

Summary

Environmental Protection and Compliance, Environmental Stewardship (EPC-ES) has determined that materials associated with technical area 3, Buildings 16 and 18 (collectively known as TA-3-16) (Figure 1) do not meet the criteria for unrestricted release to the public under Department of Energy (DOE) Order 458.1, Radiation Protection for the Public and the Environment (DOE 2020) and are to be treated as Low Level Waste (LLW). These conclusions are based on the known history of the building combined with radiation survey data collected in 2020 and 2021, and findings are consistent with DOE Order 458.1 and Los Alamos National Laboratory (LANL) Functional Series Document EPC-ES-FSD-004, Environmental Radiation Protection (LANL 2020a). Sampling and data analysis, as described in this report, were sufficient to meet measurement quality objectives under the Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME) manual (MARSAME 2000) and LANL procedures (LANL 2020b). Final approvals for waste disposition will come from LANL's Waste Management Program.

The scope of this final release report includes building TA-3-16 (Figure 1). Floorplans for TA-3-16 are provided in Figures 2-5. Metal materials included in this report are not subject to the DOE metal moratorium. While MARSAME provides guidance on statistical sampling for residual radionuclides in bulk materials, smaller miscellaneous items can be released via the release procedures outlined in LANL Policy 121 Radiation Protection (LANL 2019).

Figure 1: Aerial view of TA-03 Building 16

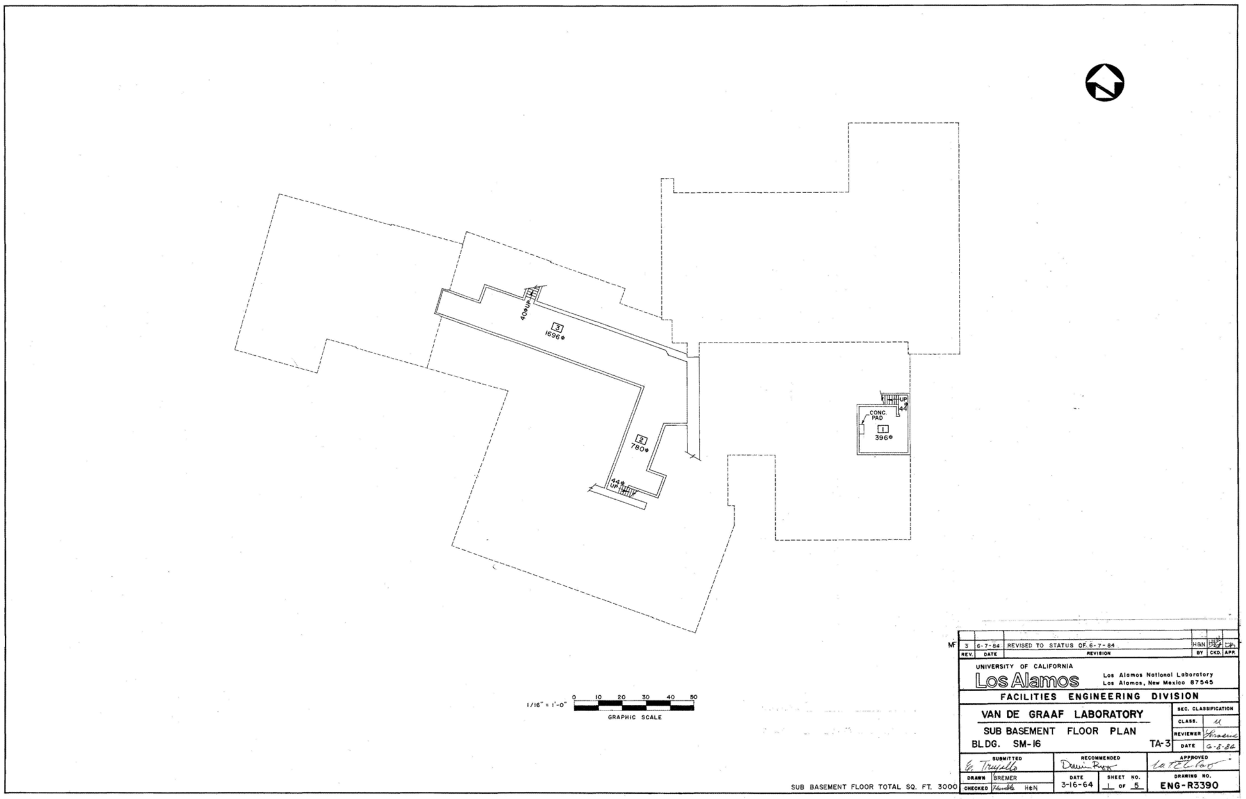

Figure 2. Sub-Basement Floor plan for building 03-0016

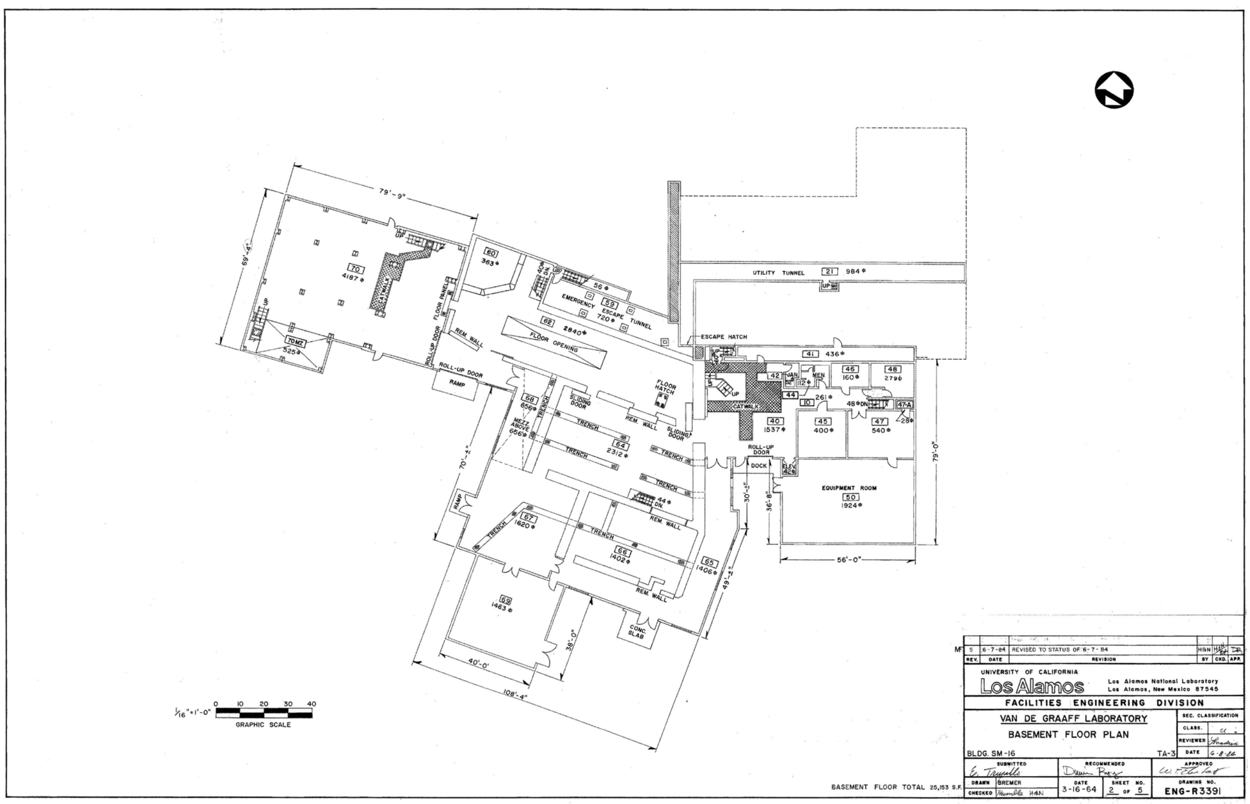

Figure 3. Basement Floor plan for building 03-0016

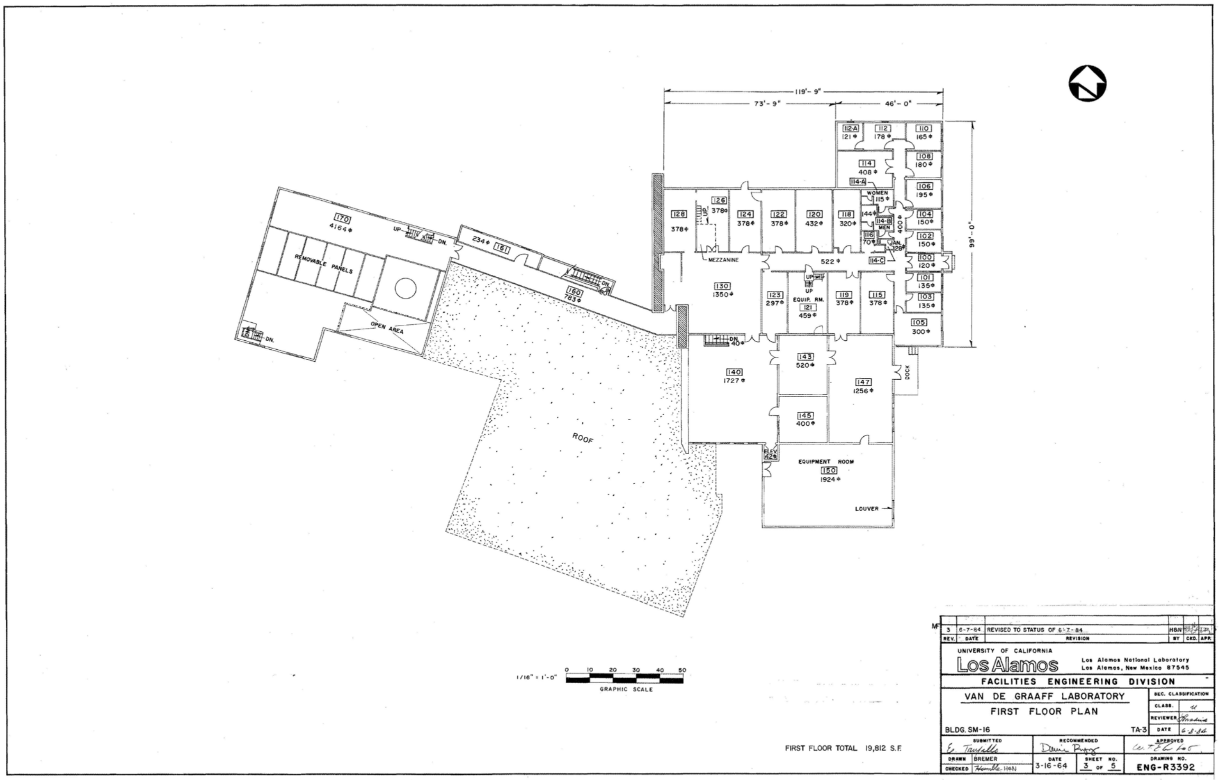

Figure 4. First Floor plan for building 03-0016

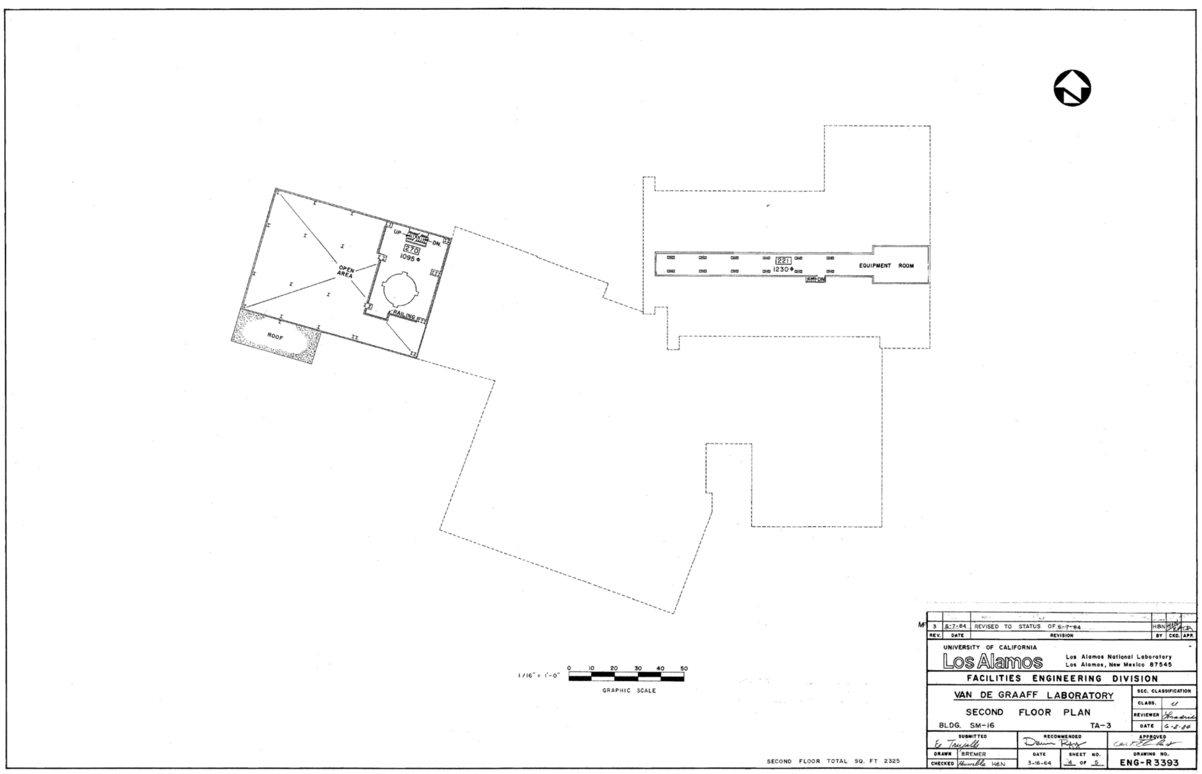

Figure 5. Second Floor plan for building 03-0016

Introduction[1]

Thousands of experiments made use of the Van de Graaff accelerators at the IBF. Most experiments involved pure physics, the study of problems and explanations of pure physical phenomena. The IBF Van de Graaff could produce consistent particle energies of 8 MeV. Over the years, the Laboratory made upgrades to the IBF and added the powerful tandem accelerator in 1965. The accelerators could either be operated separately or coupled together. This opened an energy range of more than double that of the existing accelerators.

Research fell into two categories, nuclear spectroscopy (the study of the energy level schemes of nuclei and determination of the levels' properties) and nuclear reactions (qualitative and quantitative studies of the magnitudes of the interactions of nuclei with various bombarding particles such as protons, neutrons, alpha-particles, and oxygen ions). Experiments solved a lot of the mysteries surrounding the fission process. Accelerated protons, deuterons, and heavy ions were available for experimental programs (tests), particularly triton accelerations.

SM-18 (TA-03-0018)

In 1948, SM-18 was designed to house the vertical Van de Graff accelerator built by Joseph McKibben. Construction of the facility was completed around 1950. The vertical Van De Graff accelerator was housed in the 111-foot and 11-inch tall tower section of the IBF. Experimental stations were scattered throughout the two-story structure that was part of the original construction.

A small two story addition with a mezzanine was added to the south of SM-18 in 1962. A collimator track was installed in 1966 on the 2nd floor of this structure. Beam collimation reduces uncontrolled beam losses in the machine and protect machine components and personnel against excessive irradiation. The collimator could be set up at different places along the track.

SM-16 (TA-03-0016)

Shortly after SM-18 was constructed, a 9,100 square-foot, one-story addition was constructed to house the control room, conference room, shop, drafting room, guard area, four offices, seven laboratories, and restrooms. A basement utility corridor, room 21, that was 1,340 square-feet overall and seven feet tall by nine feet wide runs through the center of the building, east to west; it is accessible from the first floor via a central stair.

Two shield walls, one was 5 feet wide by 60 feet, 6 inches long by 24 feet tall and the other was one 5 feet wide by 20 feet long by 22 feet, 10 inches tall, were constructed at the west end of the building, the side nearest the vertical accelerator. Shield walls were constructed of cast concrete and earth-filled. The purpose of the shield walls was to protect users from potential radiation hazards from operation of the Van De Graaff accelerator as well as reducing background interference during tests.

Area A - Area A was a two level structure constructed of cast concrete for both exterior and interior rooms. Spaces included an auxiliary apparatus room, a target preparation room, an assembly room, polishing room, dark room, a massive mechanical room, laboratory rooms, shop room, equipment/utilities room, control rooms, electronics room, and a computing room. These rooms were partitioned with solid reinforced concrete walls and shielding doors.

[1] Information in this section is directly from LANL (2018). Brown, C; Garcia, K. L.; Townsend, C; Schultz, E; *Historic Documentation of TA-3-0016, Smashing Atoms & Modern Physics at the Ion Beam Facility*, Volume 1. LA-UR-18-30885.

Area B - Area B housed the tandem Van de Graff. Three foot concrete shield walls surrounded the Van de Graaff on all sides creating some of the exterior walls of this area. Steel faced, magnetite filled shielding doors with large steel wheels moved on large steel tracks to close off the accelerator room during tests to keep radiation disturbances to a minimum. The structure was one story with a flat roof. A switching magnet would direct beams to any of the beam tubes used for testing through a wall constructed of movable shielding blocks that provided seven holes for the beam tubes.

Area C - This area was directly south of Area B and was also one story and had a flat roof. This area housed a charged-particle experimental vault (reaction room) that was shielded with solid, cast, concrete and a (generator room).

Area D - Several concrete shielded laboratory rooms were created in this addition to include a neutron room and a spectrometer room. The structure was one story with a flat roof and was constructed of a steel frame and sheeted with the insulated aluminum siding.

Demolition of IBF Interiors and Ancillary Facility

While the Van de Graaff accelerators are still in the building. Many of the tritium contaminated beam tubes and other ancillary equipment were removed in 2006 and 2010. The 2006 demolition consisted of interior demolition and removal of selected electrical, mechanical and plumbing systems associated with both accelerators including vacuum piping, valves, and pumps. In 2010, ancillary equipment and other items left over from programmatic operations were removed (Liechty 2017).

Radiological Conditions within the Radiological Controlled Areas

Costigan (1995) provides details of past historical results of radiological measurements made throughout the IBF. Results show elevated tritium in air (room and exhaust) and on building surfaces. In Contamination Areas, the results exceeded the surface contamination limits but not in Controlled Areas though there was detectable removable tritium in the building materials due to off gassing.

MARSAME Survey Description

Building 3-16 needs to be characterized to support future Decontamination & Demolition (D&D) of this building and supporting structures. Since the structures are still standing, the MARSSIM survey approach was utilized to perform the characterization surveys of these structures for residual radioactive contamination. However, since these structures will eventually be demolished and the waste and any recyclable materials will be sent offsite for disposal, the MARSAME requirements are utilized to evaluate the resulting characterization data for waste debris and recyclable material disposal path decisions, as appropriate.

Survey Quality Objectives

The data quality and survey completeness of the characterization survey were compared to MARSAME requirements for statistical coverage and representativeness. To ensure adequacy of survey coverage, EPC-ES used the statistical software Visual Sample Plan (VSP 2015). This software generates a MARSAME-compliant sampling plan that provides sufficient and representative data on which to base release decisions. Characterization surveys provide 1) information on the nature and extent of contamination, if any, 2) data to support evaluation of remedial alternatives and technologies, 3) data for determining if the survey plan can be optimized for use in the final survey, and 4) input for the final status survey design (MARSSIM 2002).

Fundamental assumptions for this survey plan depended upon the disposition pathway and included the following:

- The data were not assumed to be normally distributed.
- For the Authorized Limit release pathway (material released to commercial landfill or for recycle):
  - The null hypothesis, H_o, is that the survey unit is contaminated above the authorized limit (AL). "Passing" the survey unit, and releasing the material, would result from rejecting the null hypothesis.
  - Type 1 error (incorrectly rejecting the null hypothesis) would mean concluding the material was below the AL, when in fact it was contaminated above the AL.
  - Type 2 error (incorrectly failing to reject the null hypothesis) would mean concluding the material was contaminated above the AL when it was uncontaminated.

Measurements collected during the characterization survey were used as input for calculating the relative shift and other statistical parameters used in the Characterization Plan (Appendix A, Section 9.0). Type I error was set at 5% and Type II error was set at 10%, resulting in approximately 12 samples per decision unit (i.e., per room) using VSP software (see Supplement in Appendix B). Biased and scan surveys were included in MARSAME-based plans for improved coverage and better specificity using process knowledge. Based on characterization survey coverage, no additional surveys were required for the general room surveys or the exterior and roof structures. This Final Release Report and Survey Plan are being submitted for independent review by the DOE in compliance with DOE Order 458.1 prior to release.

As detailed in the Characterization Plan (Appendix A), smears for removable alpha and beta/gamma, and tritium radioactivity were taken according to procedures. Direct 1-minute measurements of alpha and beta/gamma measurements were also taken per procedure and evaluated as total surface activity.

The number and placement of sampling locations in the initial and follow up characterization surveys for the specified structures in this report were compared to MARSAME requirements for final release and were adequate in number of measurements and the spatial distribution to make valid statistically-based release decisions (see Table 1). Grid-like and bias (i.e., judgmental) sampling were performed in each room using direct counts and scan surveys. Table 1 presents a summary of the Characterization plan final status survey requirements and the corresponding survey that was actually performed.

Table 1 also provides the proposed disposition (i.e., indistinguishable from background, or LLW, if above release criteria). The rooms met the unrestricted release criteria for alpha and beta/gamma radioactivity in building materials and was indistinguishable from natural background, but a number of rooms did not meet the unrestricted release criteria for tritium and no rooms were indistinguishable from background. Therefore, the building materials are not releasable for disposition in a commercial landfill or as recycling [NMAC-SWB-20.9.2.10(10)]. The recommended disposition of materials is as LLW. Final approvals for waste disposition will come from LANL's Waste Management Program.

Table 1: Final status survey requirements compared to completed surveys. Acronyms provided at end of table.

Characterization Plan Designation			Final Status Survey Requirements			Completed			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
Bottom Floor									
3-16-10	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/15/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-40	2	walls, floors	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	25 Grid 15 Biased 10 QA	75%	LLW
3-16-41	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/21/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-42	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-44	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/22/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-45	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-46	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-47	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/22/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-47A	2	walls, shelves, floor	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/22/2021	16 Grid 15 Biased 10 QA	75%	LLW
3-16-48	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/21/2021	30 Grid 10 Biased 10 QA	75%	LLW

Characterization Plan Designation			Final Status Survey Requirements			Completed			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
3-16-50	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	32 Grid 18 Biased 10 QA	75%	LLW
3-16-62	2	walls, floor	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	55 Grid 10 Biased 10 QA	75%	LLW
3-16-64	2	walls, floor	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	25 Grid 10 Biased 10 QA	75%	LLW
3-16-65	2	walls, floor	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	44 Grid 6 Biased 10 QA	75%	LLW
3-16-66	2	walls, floor	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	25 Grid 15 Biased 10 QA	75%	LLW
3-16-67	2	walls, floors, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-69	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-70	2	walls, floor, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta	4/24/2021	30 Grid 10 Biased 10 QA	75%	LLW
First Floor									
3-16-100	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	2/1/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-101	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	1/27/2021	30 Grid 5 Biased 5 QA	10%	LLW

Characterization Plan Designation			Final Status Survey Requirements			Completed			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
3-16-102	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	1/27/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-103	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	2/1/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-104	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	1/25/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-105	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	2/1/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-106	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	1/14/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-108	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	2/2/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-110	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	2/2/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-112	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	2/3/2021	30 Grid 5 Biased 5 QA	10%	LLW
3-16-112A	3	floor, walls, ceiling	~25 Grid ~5 Biased ~5 QA	<10%	Alpha Beta H-3	2/3/2021	30 Grid 5 Biased 5 QA	10%	LLW

Characterization Plan Designation			Final Status Survey Requirements			Completed			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
3-16-114	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	2/9/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-114A	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/3/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-114B	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/3/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-114C	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/8/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-115	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	2/22/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-116	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/5/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-118	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	2/24/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-119	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	2/23/2021	30 Grid 10 Biased 10 QA	75%	LLW

Characterization Plan Designation			Final Status Survey Requirements			Completed			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
3-16-120	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/15/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-121	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/7/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-122	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/2/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-123	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/5/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-124	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/2/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-126	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/16/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-128	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/16/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-130	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/16/2021	30 Grid 10 Biased 10 QA	75%	LLW

Characterization Plan Designation			**Final Status Survey Requirements**			**Completed**			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
3-16-140	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/16/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-143A	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/11/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-143B	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/15/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-145A	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/11/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-145B	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/15/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-147	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	3/2/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-150	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/7/2021	30 Grid 1- Biased 10 QA	75%	LLW
3-16-160	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/6/2021	30 Grid 10 Biased 10 QA	75%	LLW

Characterization Plan Designation			Final Status Survey Requirements			Completed			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
3-16-161	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/5/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-170	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/7/2021	30 Grid 10 Biased 10 QA	75%	LLW
3-16-hallway	2	floor, walls, ceiling	~25 Grid ~10 Biased ~10 QA	<75%	Alpha Beta H-3	4/15/2021	30 Grid 10 Biased 10 QA	75%	LLW
Exterior									
3-16-exterior	3	walls	~112 Grid	<75%	Alpha Beta	5/14/2021	100 Grid	75%	LLW

Acronyms:
LLW – Low Level Waste
QA – Quality Assurance measurement

Measurement Quality Objectives

1. Rooms were classified as non-impacted (no reasonable potential for containing radioactivity in excess of natural background), Class 2 (potential for contamination and possibly near surface contamination limits), and Class 3 (minimal potential for contamination) consistent with MARSAME. Sampling and analysis protocol for all items was consistent with LANL policy and procedures (LANL 2020b). Direct measurements were made using a Ludlum 43-93 Alpha/Beta probe coupled with a Thermo RadEye instrument. This instrument is appropriate for alpha/beta surface contamination measurements. The minimum detectable activity (MDAs) for the direct surveys were below the release limits in Table 10-2 in EPC-ES-FSD-004, as required. Smears were used to collect removable samples and were counted on a Berthold Model LB770 Alpha/Beta Counter with MDAs that were approximately 6 dpm alpha and 11 dpm beta.

2. This assessment confirms that the measurement quality objectives were met for the disposition of the materials, specifically:

   a. Appropriate instrumentation and techniques were used for the measurements and the expected radionuclides (uranium was identified as the dominant radionuclides for surface contamination);
   b. Scanning surveys (< 5% coverage for non-impacted, at least 10% for Class 3 and Class 2) were used to search for hot spots, as documented in the characterization surveys;
   c. Instruments were calibrated, response checked and background measurements were within expected ranges; and
   d. Minimum detectable concentrations of the measurements were calculated to be below the surface radioactivity values in Table 10-2 of EPC-ES-FSD-004.

Statistical Objectives for Disposition Pathways

Depending on the disposition pathway, the objectives of the measurements were to confirm, within the stated statistical confidence limits, that:

1. Measurements of total and removable surface radioactivity are below Table 10-2 values in EPC-ES-FSD-004; and/or
2. Potential residual radioactive contamination is within background levels [i.e. sample measurement distribution is statistically indistinguishable from background distribution (IFB)].

Potential disposition pathways for this project included:

1. Release of metal for recycle using the Authorized Limits for surface radioactivity found in EPC-ES-FSD-004 Table 10-2 and as low as reasonably achievable (ALARA) considerations.
2. Release of concrete for recycle using a release criterion of IFB.
3. Release of construction and demolition debris (all other material) for disposal at commercial/municipal landfills using a release criterion of IFB.
4. Low Level Waste disposal for any material that does not meet release requirements for any of the above (items 1-3) disposition pathways.

Data Analysis

Authorized Limit Release Pathway

Materials bearing surface radioactivity greater than the MDA were evaluated by comparison to the preapproved ALs found in Table 10-2 of EPC-ES-FSD-004. The radionuclide of concern for surface radioactivity was tritium (beta measurements), which has preapproved release limits of 10,000 dpm/100 cm^2 removable beta activity.

Decision Criteria for AL pathway:

- If all measurements are 1) ≤ AL, or 2) < table values for items with surface contamination potential only (e.g. Table 10-2 in EPC-ES-FSD-004), then no further action is required and the items are candidates for unrestricted release.
- If all measurements or the 95% upper confidence limit (UCL) are > the AL, then the item is not a candidate for release through the AL release pathway and the items can be considered for decontamination or decay in storage followed by resampling before it can be released.
- If the UCL for a set of measurements is below the AL, but some individual measurements are above the AL, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is used, and if contamination is not present in background, use the Sign Test.

Indistinguishable From Background Pathway

Materials bearing surface radioactivity greater than the MDA were evaluated by comparison to the reference background values for common construction materials with naturally occurring radioactive material (NORM) found in Bullock et al. (2019), see Attachment 1. Without pre-approved volumetric limits, the IFB release criterial were applied for these releases.

Decision Criteria for IFB pathway:

- If all measurements are: 1) ≤ detectable levels, or 2) < reference background values such as the 95% UCL, then no further action is required and the items are candidates for unrestricted release.
- If all measurements are > 95%UCL of background, then the item is not a candidate for release through the IFB pathway and the item can be considered for decontamination or decay in storage followed by resampling before it can be released.
- If the mean for a set of measurements is below the 95% UCL background level, but some individual measurements are above the 95%UCL level, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is suggested, and if contamination is not present in background, use the Sign Test.

Results

Surface Sampling Results

Results of surveys conducted on building materials are provided in Table 2, where they are grouped by room and then compared to AL criteria. These surface radioactivity results show that most of the materials were below the limits found in EPC-ES-FSD-004 Table 10-2. However, the tritium results were not indistinguishable from background.

Table 2: Summary statistics for gross alpha and beta surface radioactivity levels in sampling and release decisions. Units are dpm/100 cm^2. Acronyms provided at end of table.

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
TA-3-16 Bottom Floor									
3-16-10	removable	alpha	40	0.3	0.6	2.4	0.8	20	< AL, LLW
		beta	40	2.9	4.3	22.4	5.8	1000	< AL, LLW
		H-3	35	52	65	321	152	10,000	< AL, LLW
	total	alpha	50	48	18	106	52	100	< AL, LLW
		beta	50	1545	354	2176	1629	5000	< AL, LLW
3-16-40	removable	alpha	40	0.6	0.9	3.5	1.2	20	<AL, LLW
		beta	40	13	24	152	30	1000	< AL, LLW
		H-3	40	190	340	1510	425	10,000	< AL, LLW
	total	alpha	50	34	12	54	37	100	< AL, LLW
		beta	50	1323	376	2157	1412	5000	< AL, LLW
3-16-41	removable	alpha	40	0.4	0.6	2.4	0.8	20	< AL, LLW
		beta	40	4	11	68	11	1000	< AL, LLW
		H-3	35	52	89	402	108	10,000	< AL, LLW
	total	alpha	50	42	18	91	46	100	< AL, LLW
		beta	50	1284	336	2306	1363	5000	< AL, LLW
3-16-42	removable	alpha	40	0.3	0.7	3.6	0.8	20	< AL, LLW
		beta	40	2.4	2.8	9.8	4.3	1000	< AL, LLW
		H-3	40	596	1005	4632	841	10,000	< AL, LLW
	total	alpha	50	35	16	72	40	100	< AL, LLW
		beta	50	1319	325	2009	1396	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
3-16-44	removable	alpha	40	0.4	0.7	2.5	0.9	20	< AL, LLW
		beta	40	2	2.2	8.2	3.5	1000	< AL, LLW
		H-3	35	104	111	434	179	10,000	< AL, LLW
	total	alpha	50	46	26	149	52	100	< AL, LLW
		beta	50	1649	374	2199	1738	5000	< AL, LLW
3-16-45	removable	alpha	40	0.3	0.5	1.2	0.6	20	< AL, LLW
		beta	40	343	1859	11777	1624	1000	< AL, LLW
		H-3	40	5335	24151	153473	21980	10,000	< AL, LLW
	total	alpha	50	25	11	48	27	100	< AL, LLW
		beta	50	1242	623	4982	1390	5000	< AL, LLW
3-16-46	removable	alpha	40	0.6	1.5	8.7	1.7	20	< AL, LLW
		beta	40	6.2	7.5	32	11	1000	< AL, LLW
		H-3	40	45	44	180	59	10,000	< AL, LLW
	total	alpha	50	39	14	80	42	100	< AL, LLW
		beta	50	1320	240	2007	1377	5000	< AL, LLW
3-16-47	removable	alpha	40	0.9	1.1	3.9	1.6	20	< AL, LLW
		beta	39	2.3	2.6	12	4.1	1000	< AL, LLW
		H-3	35	48	61	260	82	10,000	< AL, LLW
	total	alpha	50	39	15	78	43	100	< AL, LLW
		beta	50	1443	429	2472	1545	5000	< AL, LLW
3-16-47A	removable	alpha	31	0.6	1	3.6	1.4	20	< AL, LLW
		beta	31	2.9	2.8	8.4	5.1	1000	< AL, LLW
		H-3	32	30	29	107	54	10,000	< AL, LLW
	total	alpha	41	33	11	64	35	100	< AL, LLW
		beta	41	1385	361	2167	1480	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
3-16-48	removable	alpha	40	0.7	1	3.8	1.4	20	< AL, LLW
		beta	40	2.3	2.5	8.5	4	1000	< AL, LLW
		H-3	35	44	55	250	58	10,000	< AL, LLW
	total	alpha	50	32	15	72	36	100	< AL, LLW
		beta	50	1492	450	2291	1599	5000	< AL, LLW
3-16-50	removable	alpha	50	0.7	1	3.7	1.3	20	< AL, LLW
		beta	50	2.5	2.9	11.5	4.3	1000	< AL, LLW
		H-3	50	83	307	2163	272	10,000	< AL, LLW
	total	alpha	60	34	13	65	37	100	< AL, LLW
		beta	60	1265	384	2157	1348	5000	< AL, LLW
3-16-62	removable	alpha	65	0.1	0.4	1.2	0.3	20	< AL, LLW
		beta	65	2.5	3.8	26	4.6	1000	< AL, LLW
		H-3	65	163	621	5001	452	10,000	< AL, LLW
	total	alpha	75	55	22	119	59	100	< AL, LLW
		beta	75	1008	250	2094	1056	5000	< AL, LLW
3-16-64	removable	alpha	40	0.7	0.9	3.6	1.3	20	< AL, LLW
		beta	40	11	48	304	44	1000	< AL, LLW
		H-3	40	138	199	1073	254	10,000	< AL, LLW
	total	alpha	50	39	19	76	43	100	< AL, LLW
		beta	50	889	356	1535	1109	5000	< AL, LLW
3-16-65	removable	alpha	50	0.6	0.8	2.5	1.1	20	< AL, LLW
		beta	50	2.3	2.1	8.8	3.6	1000	< AL, LLW
		H-3	50	83	131	628	152	10,000	< AL, LLW
	total	alpha	60	33	17	86	37	100	< AL, LLW
		beta	60	1081	247	1706	1134	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
3-16-66	removable	alpha	38	0.7	0.8	2.5	1.3	20	< AL, LLW
		beta	38	3.5	3.1	12	4.4	1000	< AL, LLW
		H-3	40	357	935	5612	449	10,000	< AL, LLW
	total	alpha	48	49	24	94	55	100	< AL, LLW
		beta	48	1037	151	1315	1074	5000	< AL, LLW
3-16-67	removable	alpha	40	0.9	1.1	3.9	1.6	20	< AL, LLW
		beta	39	9.2	22	134	24	1000	< AL, LLW
		H-3	35	390	1462	8611	1294	10,000	< AL, LLW
	total	alpha	50	36	17	87	40	100	< AL, LLW
		beta	50	1034	178	1529	1077	5000	< AL, LLW
3-16-69	removable	alpha	40	0.8	1.1	5	1.6	20	< AL, LLW
		beta	40	3.2	4.1	17	6	1000	< AL, LLW
		H-3	35	68	147	852	97	10,000	< AL, LLW
	total	alpha	45	37	17	87	41	100	< AL, LLW
		beta	45	965	202	1452	1015	5000	< AL, LLW
3-16-70	removable	alpha	40	0.7	1.1	5.2	1.5	20	< AL, LLW
		beta	40	3.3	4	17	6	1000	< AL, LLW
		H-3	35	56	67	402	84	10,000	< AL, LLW
	total	alpha	49	23	12	50	26	100	< AL, LLW
		beta	49	846	240	1554	903	5000	< AL, LLW
TA-3-16 First Floor									
03-16-100	removable	alpha	35	1	1.2	4.9	1.9	20	< AL, LLW
		beta	35	1.8	1.9	8.1	3.2	1000	< AL, LLW
		H-3	35	32	16	109	36	10,000	< AL, LLW
	total	alpha	40	29	13	67	33	100	< AL, LLW
		beta	40	939	160	1275	984	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
03-16-101	removable	alpha	35	0.5	0.8	3.6	1.1	20	< AL, LLW
		beta	35	0.9	1.5	6.8	2	1000	< AL, LLW
		H-3	35	24	11	44	27	10,000	< AL, LLW
	total	alpha	40	23	15	87	27	100	< AL, LLW
		beta	40	952	204	1404	1006	5000	< AL, LLW
03-16-102	removable	alpha	35	0.4	0.9	3.5	1	20	< AL, LLW
		beta	35	0.7	1.1	5	1.6	1000	< AL, LLW
		H-3	35	25	12	52	28	10,000	< AL, LLW
	total	alpha	40	24	13	46	34	100	< AL, LLW
		beta	40	1020	205	1694	1075	5000	< AL, LLW
03-16-103	removable	alpha	35	0.3	0.9	3.7	1	20	< AL, LLW
		beta	35	1.9	2.3	7.8	3.5	1000	< AL, LLW
		H-3	35	27	12	64	31	10,000	< AL, LLW
	total	alpha	40	34	16	72	38	100	< AL, LLW
		beta	40	952	124	1255	985	5000	< AL, LLW
03-16-104	removable	alpha	35	0.1	0.3	1.2	0.3	20	< AL, LLW
		beta	35	1.4	1.8	7.1	2.7	1000	< AL, LLW
		H-3	35	42	10	68	45	10,000	< AL, LLW
	total	alpha	40	22	8	39	24	100	< AL, LLW
		beta	40	1015	165	1475	1059	5000	< AL, LLW
03-16-105	removable	alpha	35	0.4	0.8	3.7	1	20	< AL, LLW
		beta	35	1.3	2	7.8	2.8	1000	< AL, LLW
		H-3	35	41	52	332	80	10,000	< AL, LLW
	total	alpha	40	29	14	67	33	100	< AL, LLW
		beta	40	1058	272	1993	1131	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
03-16-106	removable	alpha	35	0.4	0.7	2.5	0.9	20	< AL, LLW
03-16-106	removable	beta	35	1.8	2.7	13.3	3.8	1000	< AL, LLW
03-16-106	removable	H-3	35	21	9	43	24	10,000	< AL, LLW
03-16-106	total	alpha	40	29	10	48	32	100	< AL, LLW
03-16-106	total	beta	40	1182	316	2062	1266	5000	< AL, LLW
03-16-108	removable	alpha	35	0.3	0.9	3.7	1	20	< AL, LLW
03-16-108	removable	beta	35	1.3	1.8	6.7	2.7	1000	< AL, LLW
03-16-108	removable	H-3	35	27	14	85	31	10,000	< AL, LLW
03-16-108	total	alpha	40	29	17	64	34	100	< AL, LLW
03-16-108	total	beta	40	1392	304	1914	1473	5000	< AL, LLW
03-16-110	removable	alpha	35	0.5	0.7	3.6	1	20	< AL, LLW
03-16-110	removable	beta	35	1.3	1.9	7.4	2.7	1000	< AL, LLW
03-16-110	removable	H-3	35	26	12	70	30	10,000	< AL, LLW
03-16-110	total	alpha	40	28	15	67	32	100	< AL, LLW
03-16-110	total	beta	40	1411	372	2044	1510	5000	< AL, LLW
03-16-112	removable	alpha	35	0.3	0.6	2.4	0.7	20	< AL, LLW
03-16-112	removable	beta	35	2.1	2.3	9.1	3.8	1000	< AL, LLW
03-16-112	removable	H-3	35	23	12	50	27	10,000	< AL, LLW
03-16-112	total	alpha	40	28	11	58	31	100	< AL, LLW
03-16-112	total	beta	40	1630	314	2163	1713	5000	< AL, LLW
03-16-112A	removable	alpha	35	0.5	0.7	2.4	1	20	< AL, LLW
03-16-112A	removable	beta	35	0.9	1.4	5.7	1.9	1000	< AL, LLW
03-16-112A	removable	H-3	35	21	10	41	23	10,000	< AL, LLW
03-16-112A	total	alpha	40	24	12	50	32	100	< AL, LLW
03-16-112A	total	beta	40	1419	326	2226	1505	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
03-16-114	removable	alpha	40	0.4	0.7	2.4	0.9	20	< AL, LLW
		beta	40	4.2	4.2	15	7.1	1000	< AL, LLW
		H-3	35	28	10	45	31	10,000	< AL, LLW
	total	alpha	50	22	11	44	25	100	< AL, LLW
		beta	50	1452	470	2299	1563	5000	< AL, LLW
03-16-114A	removable	alpha	40	0.3	0.6	2.4	0.7	20	< AL, LLW
		beta	40	1.1	1.7	7.8	2.3	1000	< AL, LLW
		H-3	35	8	8	23	11	10,000	< AL, LLW
	total	alpha	50	25	14	67	28	100	< AL, LLW
		beta	50	1199	421	2031	1298	5000	< AL, LLW
03-16-114B	removable	alpha	40	0.4	0.6	2.4	0.8	20	< AL, LLW
		beta	40	1.1	1.4	4.5	2	1000	< AL, LLW
		H-3	35	52	25	118	59	10,000	< AL, LLW
	total	alpha	50	28	17	94	38	100	< AL, LLW
		beta	50	1165	394	2150	1259	5000	< AL, LLW
03-16-114C	removable	alpha	15	0.3	0.5	1.1	0.8	20	< AL, LLW
		beta	15	2.7	2.4	6.7	3.8	1000	< AL, LLW
		H-3	15	27	14	64	35	10,000	< AL, LLW
	total	alpha	20	20	8	32	23	100	< AL, LLW
		beta	20	759	108	997	801	5000	< AL, LLW
03-16-115	removable	alpha	40	0.4	0.6	2.4	0.8	20	< AL, LLW
		beta	40	1.2	1.8	6.7	2.4	1000	< AL, LLW
		H-3	35	27	11	49	29	10,000	< AL, LLW
	total	alpha	50	18	9	46	20	100	< AL, LLW
		beta	50	1293	362	2139	1379	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
03-16-116	removable	alpha	40	0.3	0.6	2.5	0.7	20	< AL, LLW
		beta	40	1.5	1.8	5.4	2.7	1000	< AL, LLW
		H-3	35	432	2309	13701	1872	10,000	< AL, LLW
	total	alpha	50	36	15	74	39	100	< AL, LLW
		beta	50	902	130	1225	933	5000	< AL, LLW
03-16-118	removable	alpha	40	0.4	0.7	3.6	0.8	20	< AL, LLW
		beta	40	2.5	3.1	10.8	4.7	1000	< AL, LLW
		H-3	35	37	31	192	56	10,000	< AL, LLW
	total	alpha	50	26	12	52	29	100	< AL, LLW
		beta	50	1011	133	1300	1043	5000	< AL, LLW
03-16-119	removable	alpha	40	0.3	0.7	3.6	0.8	20	< AL, LLW
		beta	40	1.6	2.2	9.1	3.1	1000	< AL, LLW
		H-3	35	49	75	435	96	10,000	< AL, LLW
	total	alpha	50	20	9	46	22	100	< AL, LLW
		beta	50	1302	354	2059	1386	5000	< AL, LLW
03-16-120	removable	alpha	40	0.5	0.9	3.7	1.1	20	< AL, LLW
		beta	40	2	2.4	8.3	3.6	1000	< AL, LLW
		H-3	35	110	136	669	139	10,000	< AL, LLW
	total	alpha	50	30	15	63	34	100	< AL, LLW
		beta	50	899	173	1332	940	5000	< AL, LLW
03-16-121	removable	alpha	37	0.4	0.5	1.2	0.8	20	< AL, LLW
		beta	37	1.6	2.1	8.5	3.1	1000	< AL, LLW
		H-3	35	33	42	255	44	10,000	< AL, LLW
	total	alpha	47	38	15	70	42	100	< AL, LLW
		beta	47	1010	275	1687	1077	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
03-16-122	removable	alpha	40	0.5	0.8	3.8	1.1	20	< AL, LLW
		beta	40	1.3	1.6	6.3	2.4	1000	< AL, LLW
		H-3	35	32	16	91	40	10,000	< AL, LLW
	total	alpha	50	35	15	67	39	100	< AL, LLW
		beta	50	1005	170	1371	1046	5000	< AL, LLW
03-16-123	removable	alpha	40	0.2	0.5	2.4	0.6	20	< AL, LLW
		beta	40	2.5	3.4	13.3	4.9	1000	< AL, LLW
		H-3	35	34	24	148	42	10,000	< AL, LLW
	total	alpha	50	40	16	98	43	100	< AL, LLW
		beta	50	1018	186	1392	1062	5000	< AL, LLW
03-16-124	removable	alpha	40	0.3	0.6	2.4	0.7	20	< AL, LLW
		beta	40	1.2	1.7	6.1	2.3	1000	< AL, LLW
		H-3	35	17	9	33	18	10,000	< AL, LLW
	total	alpha	50	27	12	50	30	100	< AL, LLW
		beta	50	1027	153	1374	1063	5000	< AL, LLW
03-16-126	removable	alpha	35	0.3	0.5	1.2	0.6	20	< AL, LLW
		beta	35	1.7	2	5.5	3.2	1000	< AL, LLW
		H-3	35	35	37	229	68	10,000	< AL, LLW
	total	alpha	45	29	12	58	32	100	< AL, LLW
		beta	45	916	100	1146	941	5000	< AL, LLW
03-16-128	removable	alpha	35	0.2	0.5	2.4	0.5	20	< AL, LLW
		beta	35	1.4	1.9	7.6	2.9	1000	< AL, LLW
		H-3	35	47	105	617	113	10,000	< AL, LLW
	total	alpha	45	29	10	59	32	100	< AL, LLW
		beta	45	921	110	1173	949	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
03-16-130	removable	alpha	40	0.2	0.4	1.2	0.5	20	< AL, LLW
		beta	40	1.9	2.1	7.1	3.4	1000	< AL, LLW
		H-3	35	40	49	293	70	10,000	< AL, LLW
	total	alpha	50	30	14	64	34	100	< AL, LLW
		beta	50	957	134	1300	989	5000	< AL, LLW
03-16-140	removable	alpha	40	0.2	0.5	2.4	0.6	20	< AL, LLW
		beta	40	0.8	1.3	4.2	1.7	1000	< AL, LLW
		H-3	35	24	12	66	27	10,000	< AL, LLW
	total	alpha	50	46	18	78	51	100	< AL, LLW
		beta	50	1264	336	2134	1344	5000	< AL, LLW
03-16-143A	removable	alpha	40	0.2	0.4	1.1	0.5	20	< AL, LLW
		beta	40	1.1	1.6	5.9	2.3	1000	< AL, LLW
		H-3	35	33	17	79	37	10,000	< AL, LLW
	total	alpha	50	38	14	67	41	100	< AL, LLW
		beta	50	1274	264	1842	1336	5000	< AL, LLW
03-16-143B	removable	alpha	40	0.6	1	5	1.3	20	< AL, LLW
		beta	40	1.5	2	6.1	2.9	1000	< AL, LLW
		H-3	35	31	16	80	35	10,000	< AL, LLW
	total	alpha	50	23	10	48	25	100	< AL, LLW
		beta	50	1319	312	1897	1398	5000	< AL, LLW
03-16-145A	removable	alpha	40	0.3	0.7	2.4	0.8	20	< AL, LLW
		beta	40	1.4	2	7.1	2.8	1000	< AL, LLW
		H-3	35	24	16	88	79	10,000	< AL, LLW
	total	alpha	50	43	15	75	46	100	< AL, LLW
		beta	50	1616	346	2356	1697	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
03-16-145B	removable	alpha	40	0.4	0.7	3.7	0.9	20	< AL, LLW
		beta	40	1.2	1.7	7.5	2.4	1000	< AL, LLW
		H-3	35	38	26	161	44	10,000	< AL, LLW
	total	alpha	50	43	17	86	47	100	< AL, LLW
		beta	50	1557	396	2072	1651	5000	< AL, LLW
03-16-147	removable	alpha	36	0.4	0.7	2.4	0.8	20	< AL, LLW
		beta	40	1.5	2	8.7	2.9	1000	< AL, LLW
		H-3	35	29	16	77	66	10,000	< AL, LLW
	total	alpha	45	28	12	56	31	100	< AL, LLW
		beta	45	1215	231	1740	1273	5000	< AL, LLW
03-16-150	removable	alpha	40	0.3	0.6	2.4	0.8	20	< AL, LLW
		beta	40	2	2.1	7	3.4	1000	< AL, LLW
		H-3	35	33	50	280	141	10,000	< AL, LLW
	total	alpha	50	31	11	54	34	100	< AL, LLW
		beta	50	1031	186	1446	1075	5000	< AL, LLW
03-16-160	removable	alpha	40	0.3	0.5	2.4	0.6	20	< AL, LLW
		beta	40	3	4	13.3	5.7	1000	< AL, LLW
		H-3	35	16	11	49	27	10,000	< AL, LLW
	total	alpha	50	37	16	112	41	100	< AL, LLW
		beta	50	893	213	1317	944	5000	< AL, LLW
03-16-161	removable	alpha	40	0.4	0.8	3.7	0.9	20	< AL, LLW
		beta	40	2.4	2.3	7.4	4	1000	< AL, LLW
		H-3	35	29	20	112	35	10,000	< AL, LLW
	total	alpha	50	41	22	100	46	100	< AL, LLW
		beta	50	860	233	1796	916	5000	< AL, LLW

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
03-16-170	removable	alpha	40	0.4	0.7	2.5	0.8	20	< AL, LLW
		beta	40	2	2.4	7.8	3.7	1000	< AL, LLW
		H-3	35	27	23	113	59	10,000	< AL, LLW
	total	alpha	50	33	15	70	36	100	< AL, LLW
		beta	50	692	128	1183	723	5000	< AL, LLW
03-16-hallway	removable	alpha	40	0.2	0.4	1.2	0.5	20	< AL, LLW
		beta	40	1.7	3.1	18	3.8	1000	< AL, LLW
		H-3	35	1211	2706	15187	1833	10,000	< AL, LLW
	total	alpha	50	35	14	64	38	100	< AL, LLW
		beta	50	973	128	1213	1003	5000	< AL, LLW
Exterior									
03-16-exterior	removable	alpha	112	0.4	0.8	4.9	0.7	20	< AL, LLW
		beta	112	1.2	1.9	7.9	2	1000	< AL, LLW
		H-3	112	13	9	33	14	10,000	< AL, LLW
	total	alpha	112	46	33	205	60	100	< AL, LLW
		beta	112	1205	343	2977	1259	5000	< AL, LLW

Acronyms:
AL – Authorized Limit
LLW – Low Level Waste
Max – Maximum
n – Number of samples
STD – Standard Deviation
UCL – Upper Confidence Level (taken as the 95% upper-bound estimate of the mean)

Conclusions

Given the process knowledge and survey data presented in this report package, EPC-ES concludes that the structures and materials associated with TA-03 Building 16 cannot be free released under DOE Order 458.1. Final waste disposition decisions for radiological and non-radiological constituents require appropriate approvals from the waste management coordinator.

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Attachments & Appendices

Attachment 1: Background Material Values for RadEye SX with Ludlum 43-93.

Appendix A: TA-03 Building 0016 D&D MARSSIM Characterization Plan, Structures: TA 03-0016

Appendix B: Supplement to Characterization Plan for 3-16: MARSSIM Statistical Analysis, Output from VSP

Attachment 1: Background Material Values for RadEye SX with Ludlum 43-93

Summary statistics for measured total surface activities in various common construction materials. Units of measurement are GROSS dpm/100 cm^2. Data from Bullock et al. (2019).

Construction Material	Mean	Maximum	Standard Deviation	95% upper confidence level for mean
Wood (n=10)				
Alpha	29	93	29	47
Beta	906	1170	147	992
Painted Metal Interior (n=27)				
Alpha	54	592	134	167
Beta	1049	1413	148	1098
Painted Metal Exterior (n=25)				
Alpha	45	73	14	50
Beta	827	1269	185	891
Beta/Alpha Ratio	18			
Rusted Metal (n=11)				
Alpha	326	569	161	415
Beta	1355	1607	211	1471
Galvanized Metal (n=8)				
Alpha	65	93	19	78
Beta	790	869	66	834
Bare Metal (n=25)				
Alpha	12	29	7	15
Beta	1237	1632	252	1324
Painted Concrete Poured Interior (n=30)				
Alpha	20	47	12	24
Beta	1547	2427	291	1638
Painted Concrete Poured Exterior (n=20)				
Alpha	26	63	13	31
Beta	1363	1688	204	1688
Bare Concrete Poured Interior (n=25)				
Alpha	27	107	32	56
Beta	1538	1948	360	1853
Bare Concrete Poured Exterior (n=20)				
Alpha	83	155	44	100
Beta	1757	2247	238	2235
Painted Cinderblock (n=25)				
Alpha	27	68	17	33
Beta	1938	2248	276	2033
Bare Cinderblock Exterior (n=20)				
Alpha	66	128	31	78
Beta	1774	2695	477	1986
Brick (n=25)				
Alpha	95	179	47	111
Beta	2153	2660	458	2311

Construction Material	Mean	Maximum	Standard Deviation	95% upper confidence level for mean
Ceiling tile (n=25)				
Alpha	23	43	10	27
Beta	1493	1854	156	1547
Floor tile (n=25)				
Alpha	9	30	7	11
Beta	1156	1460	129	1200
Porcelain (n=25)				
Alpha	59	123	25	68
Beta	2149	2621	198	2217
Ceramic Tile (n=125)				
Alpha	79	166	29	85
Beta	2077	3221	330	2143
Carpet (n=9)				
Alpha	184	600	242	687
Beta	1122	1345	144	1212
Composite Laminates[1] (n=19)				
Alpha	253	1423	392	645
Beta	1193	2100	311	1315
Painted Wallboard (n=7)				
Alpha	178	601	260	1157
Beta	1020	1507	273	1221
Stucco (n=7)				
Alpha	46	53	6	51
Beta	1099	1245	120	1188
Glass (n=5)				
Alpha	13	17	3	16
Beta	940	997	58	995
Rubber (n=25)				
Alpha	17	39	9	20
Beta	1133	1770	318	1255
Roofing Composite[2] (n=10)				
Alpha	44	88	27	60
Beta	1344	1596	172	1444

[1] Composite Laminates: laminated tables, laminated counter, plastic, and linoleum

[2] Composite Roofing: Asphalt and gravel

Appendix A
TA-03 Building 0016 D&D MARSSIM Characterization Plan
Structures: TA 03-0016

TA-03 Building 0016 D&D MARSSIM Characterization Plan
Structures: TA 03-0016

Prepared by: Christine Bullock, Mary Jo Chastenet, Jeffrey Whicker,
EPC-ES, Environmental Health Physicist

1.0 Purpose and Scope of the TA-03 Building 0016 D&D MARSSIM Characterization Plan

TA-03 Building 0016 (TA-03-0016), Ion Beam Facility (IBF) needs to be characterized to support future Decontamination & Demolition (D&D) of this building and supporting structures (Figure 1). Since the structures are still standing, the MARSSIM-type survey approach will be utilized to perform the characterization surveys of these structures for residual radioactive contamination. However, since these structures will eventually be demolished and the waste and any recyclable materials will be sent offsite for disposal, the MARSAME requirements will be utilized to evaluate the resulting characterization data for waste debris and recyclable material disposal path decisions, as appropriate.

Figure 1. Overhead view of Building 03-0016.

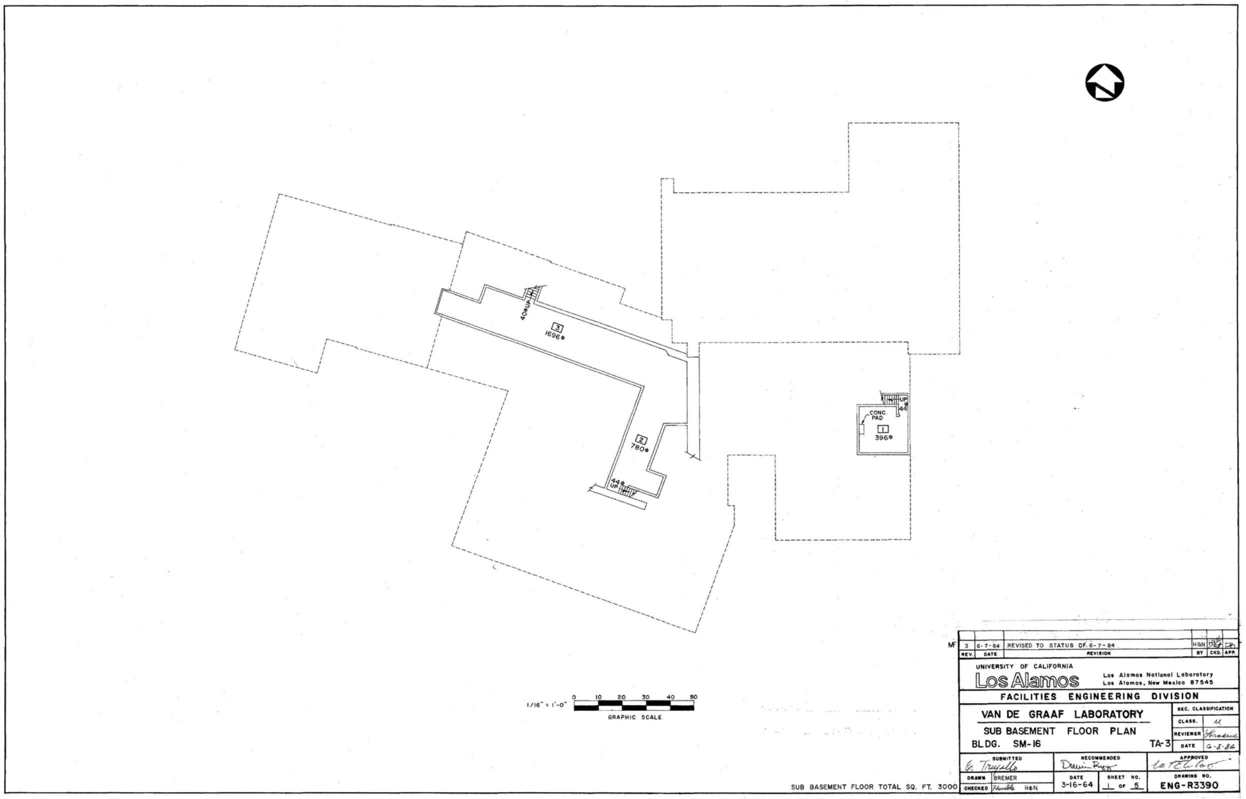


Figure 2. Sub-Basement Floor plan for building 03-0016

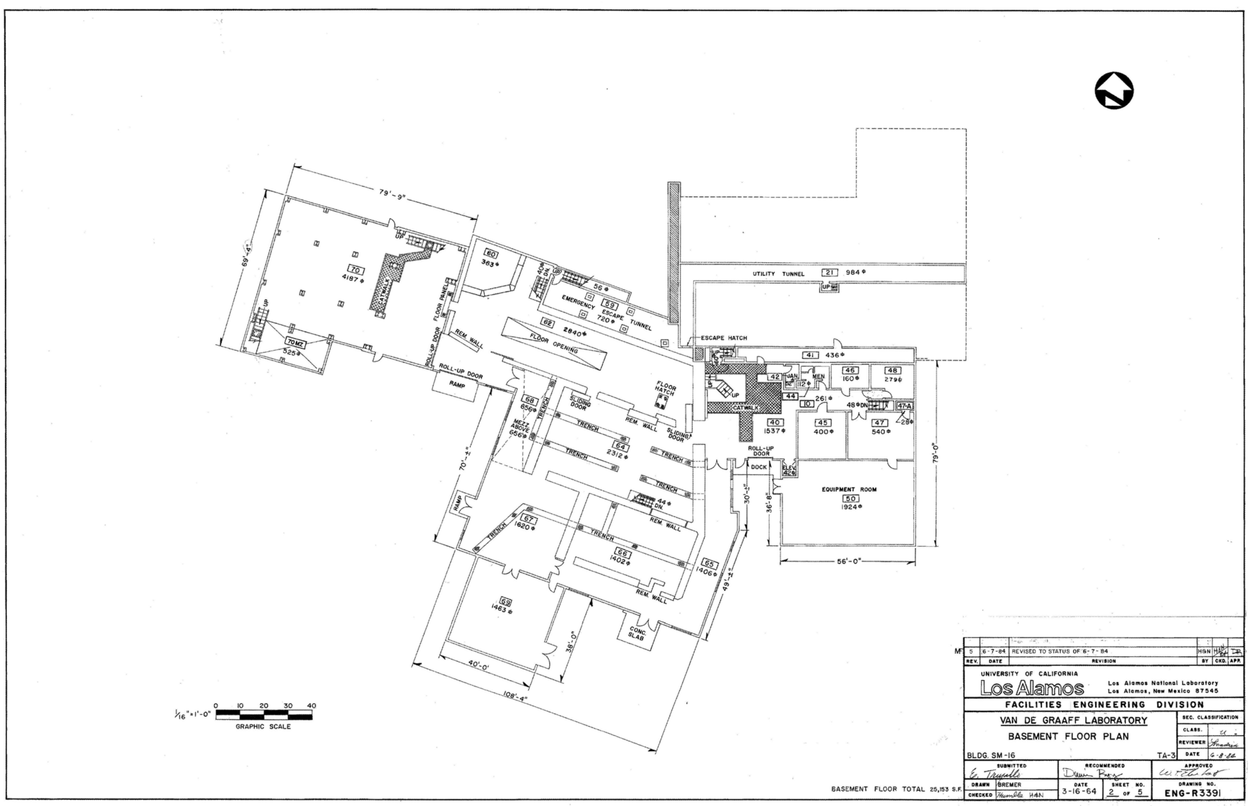


Figure 3. Basement Floor plan for building 03-0016

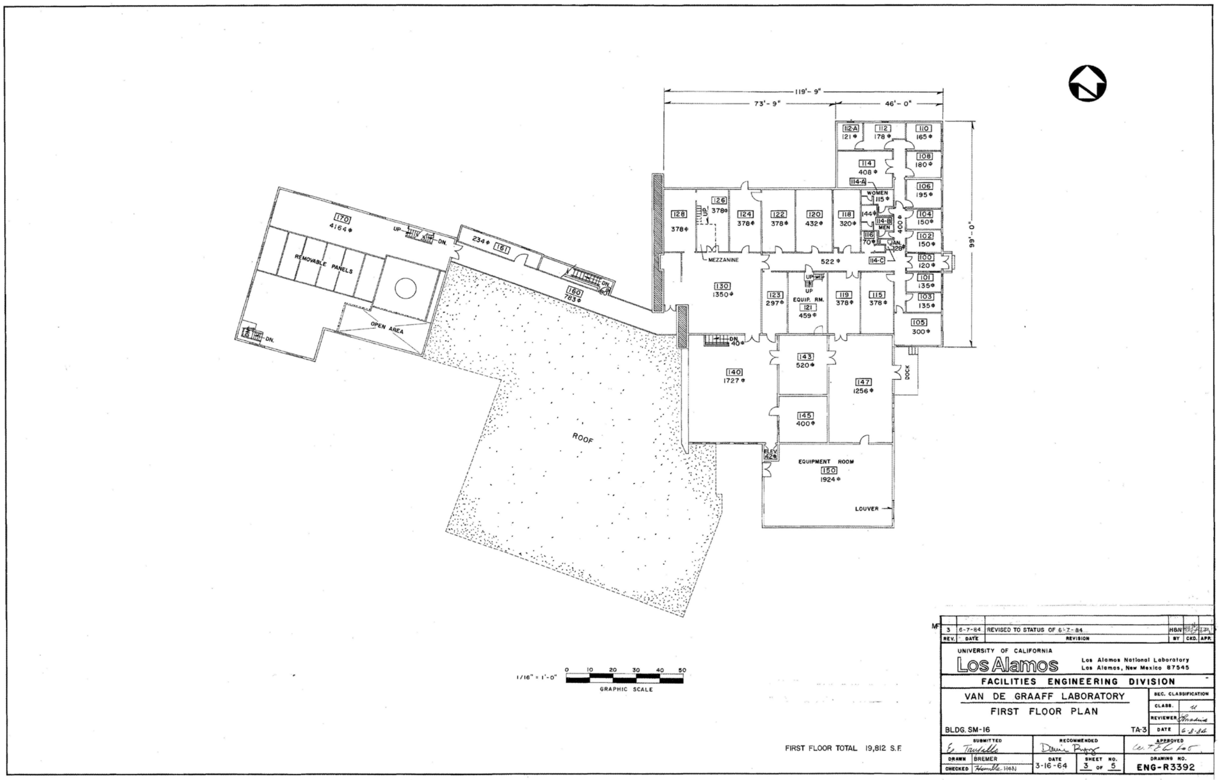


Figure 4. First Floor plan for building 03-0016

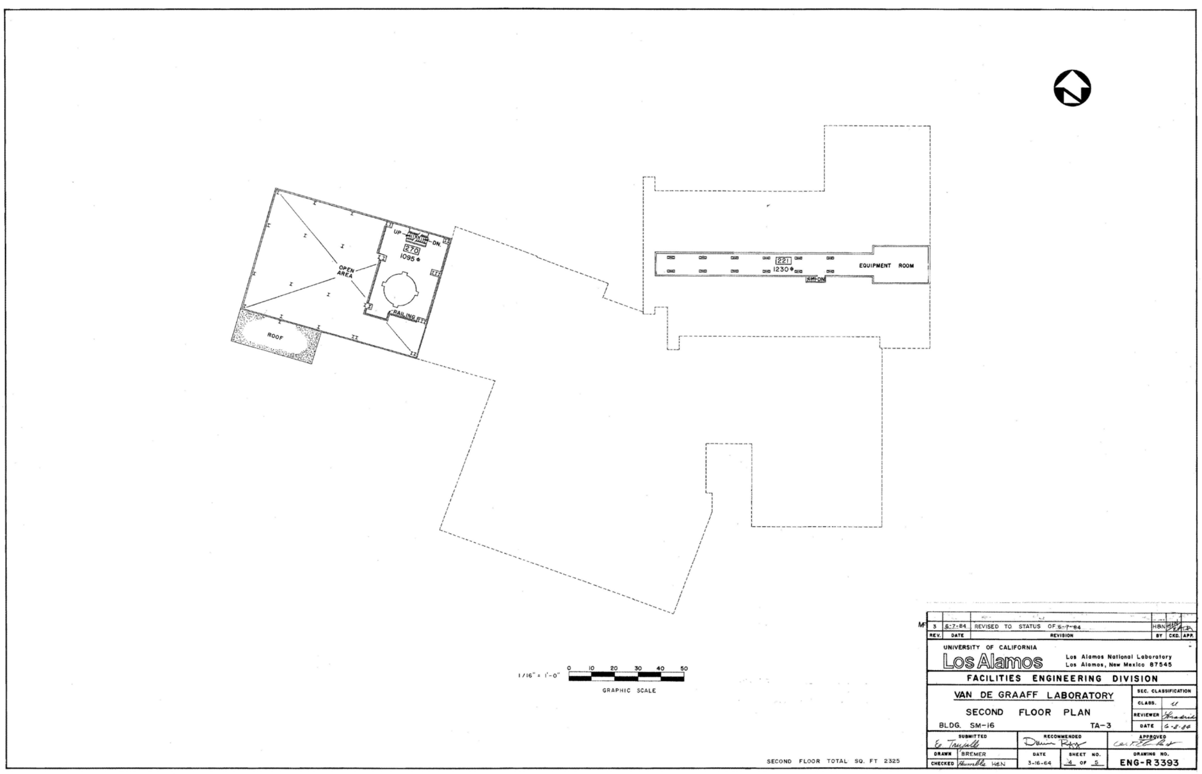


Figure 5. Second Floor plan for building 03-0016

1.1. Per MARSSIM Section 2.4, there are six principal steps in the MARSSIM Radiation Survey and Site Investigation Process:

- Site Identification
- Historical Site Assessment (HSA)
- Scoping Survey
- Characterization Survey
- Remedial Action Support Survey
- Final Status Survey

1.2. All six of these principal steps could be used in the D&D process for TA-03-0016. The first two principal steps (i.e., site identification and HSA) have already been completed and the results are detailed in this document. The purpose of this Plan is to satisfy the 3rd and 4th principal steps (scoping and characterization) to assess for radiological impact in these structures, and, if impacted, to characterize the potential contamination. These two MARSSIM survey types have been combined in this plan and will only be referred to as characterization surveys.

1.3. The MARSSIM HSA information for these structures is contained is Section 2 below. Prior operational and decommissioning information suggests this building does contain radiological contamination. The MARSSIM surveys will be used to assess for the possibility of residual contamination. The survey results will be evaluated for radioactive contamination against MARSAME release requirements, and if release requirements are met, the debris from the building is a candidate for unrestricted release under DOE Order 458.1.

1.4. If surveys measure radioactive contamination, per MARSSIM Chapter 2, Section 2.4.4., "If an area could be classified as Class 1 or Class 2 for the final status survey, based on the HSA and scoping survey results, a characterization survey is warranted. This type of survey is a detailed radiological environmental characterization of the area." Based on the HSA of the TA-03-0016 building and supporting structures, Class 1, Class 2, and Class 3 final status survey units are likely. Therefore, a characterization survey structure was used as described in sections 1.5 through 1.8.

1.5. Per MARSSIM Chapter 2, Section 2.4.4., the primary objectives of a characterization survey are to:

- Determine the nature and extent of the contamination.
- Collect data to support evaluation of remedial alternatives and technologies.
- Evaluate whether the survey plan can be optimized for use in the final status survey.
- Provide input to the final status survey design.

1.6. Per MARSSIM Chapter 2, Section 2.4.4., "The characterization survey is the most comprehensive of all the survey types and generates the most data. This includes preparing a reference grid, systematic as well as judgment measurements, and surveys of different media (*e.g.*, surface soils, interior and exterior surfaces of buildings). The decision as to which media will be surveyed is a site-specific decision addressed throughout the Radiation Survey and Site Investigation Process."

1.7. Once the characterization survey has been completed per this Plan, the characterization data will be analyzed using the MARSAME statistical methods. The MARSAME statistical method results will be used to plan for the remedial action support surveys and/or final status surveys, as appropriate.

1.8. Notes and Assumptions:

1.8.1. This Characterization Plan was prepared in accordance with procedure EPC-ES-FSD-004, Environmental Radiation Protection, and developed using ENV-ES-TPP-001, Data Quality Objectives for Measurement of Radioactivity in or on Items for Transfer into the Public Domain.

1.8.2. The results of this survey are to be used for D&D planning purposes. Per MARSSIM Section 2.4.6, "data from other surveys conducted during the Radiation Survey and Site Investigation Process – such as scoping, characterization, and remedial action support surveys – can provide valuable information for planning a final status survey provided they are of sufficient quality." Release of building materials is contingent upon clean surfaces passing a final status survey, as appropriate.

1.8.3. The nominal release criteria for this D&D project are from EPC-ES-FSD-004 Section 1021 Table 10-2 for surface contamination (see Section 4 of this Plan). Further restrictions may be imposed by the Waste Management Coordinator.

1.8.4. Waste disposition pathways for material from D&D projects are as follows:

1.8.4.1. Contaminated material that is known or suspected to exceed regulatory limits is to be disposed of as Low Level Waste (LLW).

1.8.4.2. Radiologically encumbered metal items (items within areas posted as radiological areas) fall under the metals moratorium and may not be released.

1.8.4.3. Unencumbered metals may be released for *reuse* within the DOE complex using the Table 10-2 criteria pending an ALARA evaluation.

1.8.4.4. Unencumbered metals may be released to the public for *recycle* or *disposal* using indistinguishable from background criteria.

1.8.4.5. Clean concrete that is not volume contaminated may be released for recycle using the Table 10-2 (Table 1 this document) criteria pending an ALARA evaluation.

1.8.4.6. Other D&D debris may be released to landfill under NMED regulations using indistinguishable from background criteria.

2.0 Historical Site Assessment Information[2]

Thousands of experiments made use of the Van de Graaff accelerators at the IBF. Most experiments involved pure physics, the study of problems and explanations of pure physical phenomena. The IBF Van de Graaff

[2] Information in this section is directly from LANL (2018). Brown, C; Garcia, K. L.; Townsend, C; Schultz, E; Historic Documentation of TA-3-0016, Smashing Atoms & Modern Physics at the Ion Beam Facility, Volume 1. LA-UR-18-30885.

could produce consistent particle energies of 8 MeV. Over the years, the Laboratory made upgrades to the IBF and added the powerful tandem accelerator in 1965. The accelerators could either be operated separately or coupled together. This opened an energy range of more than double that of the existing accelerators. Research fell into two categories, nuclear spectroscopy (the study of the energy level schemes of nuclei and determination of the levels' properties) and nuclear reactions (qualitative and quantitative studies of the magnitudes of the interactions of nuclei with various bombarding particles such as protons, neutrons, alpha-particles, and oxygen ions). Experiments solved a lot of the mysteries surrounding the fission process. Accelerated protons, deuterons, and heavy ions were available for experimental programs (tests), particularly triton accelerations.

2.1. SM-18 (TA-03-0018)

In 1948, SM-18 was designed to house the vertical Van de Graff accelerator built by Joseph McKibben. Construction of the facility was completed around 1950. The vertical Van De Graff accelerator was housed in the 111-foot and 11-inch tall tower section of the IBF. Experimental stations were scattered throughout the two-story structure that was part of the original construction.

A small two story addition with a mezzanine was added to the south of SM-18 in 1962. A collimator track was installed in 1966 on the 2nd floor of this structure. Beam collimation reduces uncontrolled beam losses in the machine and protect machine components and personnel against excessive irradiation. The collimator could be set up at different places along the track.

2.2. SM-16 (TA-03-0016)

Shortly after SM-18 was constructed, a 9,100 square-foot, one-story addition was constructed to house the control room, conference room, shop, drafting room, guard area, four offices, seven laboratories, and restrooms. A basement utility corridor, room 21, that was 1,340 square-feet overall and seven feet tall by nine feet wide runs through the center of the building, east to west; it is accessible from the first floor via a central stair.

Two shield walls, one was 5 feet wide by 60 feet, 6 inches long by 24 feet tall and the other was one 5 feet wide by 20 feet long by 22 feet, 10 inches tall, were constructed at the west end of the building, the side nearest the vertical accelerator. Shield walls were constructed of cast concrete and earth-filled. The purpose of the shield walls was to protect users from potential radiation hazards from operation of the Van De Graaff accelerator as well as reducing background interference during tests.

Area A - Area A was a two level structure constructed of cast concrete for both exterior and interior rooms. Spaces included an auxiliary apparatus room, a target preparation room, an assembly room, polishing room, dark room, a massive mechanical room, laboratory rooms, shop room, equipment/utilities room, control rooms, electronics room, and a computing room. These rooms were partitioned with solid reinforced concrete walls and shielding doors.

Area B - Area B housed the tandem Van de Graff. Three foot concrete shield walls surrounded the Van de Graaff on all sides creating some of the exterior walls of this area. Steel faced, magnetite filled shielding doors with large steel wheels moved on large steel tracks to close off the accelerator room during tests to keep radiation disturbances to a minimum. The structure was one story with a flat roof. A switching magnet would direct beams to any of the beam tubes used for testing through a wall constructed of movable shielding blocks that provided seven holes for the beam tubes.

Area C - This area was directly south of Area B and was also one story and had a flat roof. This area housed a charged-particle experimental vault (reaction room) that was shielded with solid, cast, concrete and a (generator room).

Area D - Several concrete shielded laboratory rooms were created in this addition to include a neutron room and a spectrometer room. The structure was one story with a flat roof and was constructed of a steel frame and sheeted with the insulated aluminum siding.

2.3. Demolition of IBF Interiors and Ancillary Facility

While the Van de Graaff accelerators are still in the building. Many of the tritium contaminated beam tubes and other ancillary equipment were removed in 2006 and 2010. The 2006 demolition consisted of interior demolition and removal of selected electrical, mechanical and plumbing systems associated with both accelerators including vacuum piping, valves, and pumps. In 2010, ancillary equipment and other items left over from programmatic operations were removed (Liechty 2017).

2.4. Radiological Conditions within the Radiological Controlled Areas

Costigan (1995) provides details of past historical results of radiological measurements made throughout the IBF. Results show elevated tritium in air (room and exhaust) and on building surfaces. In Contamination Areas, the results exceeded the surface contamination limits but not in Controlled Areas though there was detectable removable tritium in the building materials due to off gassing.

3.0 Survey Units and Data Analysis

3.1. This Characterization Plan is designed to provide sufficient information for D&D planning and execution. If surveyors encounter contamination or unexplained increases in standard deviation or measured concentrations, further mitigation, sampling, and data analysis may be required.

3.2. Building and room maps are to be used as rough estimates of the spatial layout of the buildings. Adjustments to the survey units and/or maps may be required based on building specifics for this characterization survey and any additional surveys.

3.3. To better manage and coordinate the characterization survey process and data, survey units will be assigned as specified in Section 9. Based on the survey results, the survey units specified in Section 9.1 may be adequate for analysis for release. Alternatively, final status survey units may need to be revised or re-developed.

4.0 Nominal Release Criteria

4.1. Characterization data obtained from this survey may be used to supplement the MARSSIM final status survey if the characterization data meets final status survey Data Quality Objectives.

MARSSIM Sections 2.3, 2.4.6, 2.6, 5.1, 5.2.4, 5.3.3.1 discuss the use of characterization surveys (and other MARSSIM surveys) to supplement and augment the final status survey requirements.

4.2. In some cases, additional surveys or sampling may be required to meet all final status survey requirements (e.g., QA measurements).

4.3. Table 1. Nominal release criteria for surface contamination.

Table 1: Values from EPC-ES-FSD-004 Section 1021 Table 10-2		
Radionuclides	Value	Units
U-natural, U-235, U-238 and associated decay products (Removable)	1,000	dpm/100cm^2
U-natural, U-235, U-238 and associated decay products (Total)	5,000	dpm/100cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 (Removable)	20	dpm/100cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 (Total)	100	dpm/100cm^2
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 (Removable)	200	dpm/100cm^2
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 (Total)	1,000	dpm/100cm^2
β/γ emitters (Removable)	1,000	dpm/100cm^2
β/γ emitters (Total)	5,000	dpm/100cm^2
Tritium and Special Tritium Compounds	10,000	dpm/100cm^2

4.4. Sampling and data analysis for volumetric contamination is required based on the facility history and potential for activation of building materials. Volumetrically contaminated items may be released using a criterion of statistically indistinguishable from background (IFB), as compared to measured background radioactivity in clean materials.

5.0 General Survey Instructions

5.1. Verify characterization activities are on the applicable Plan-of-the-Day, as appropriate.

5.2. Perform a Pre-Evaluation Brief and/or Job Task Brief in accordance with P300.

5.3. Verify personnel have appropriate training for the tasks they will be performing.

5.4. Comply with applicable Radiological Work Permit (RWP) requirements, if RWP is required.

5.5. Follow applicable IWD(s), as necessary.

6.0 Survey-Specific Instructions

6.1. Follow P121, RP-SOP-37 "Surveying for Fixed and Removable Contamination", and other applicable characterization and sampling procedures. Document all survey results on the appropriate survey form(s) and the survey map(s). All direct and removable measurement results are to be reported as dpm/100cm^2. Do not use "NDA."

6.2. The number of direct and removable measurements is specified in the following survey unit and survey requirement tables for each survey unit. Survey point locations (both direct counts and smears) will be a combination of "uniformly distributed" and "biased" locations determined by the surveyors. Uniformly distributed points shall be spread across all survey unit surfaces in a uniform, even, systematic pattern (similar to a grid pattern). Survey point locations may be changed based on accessibility issues via consultation with the Project Manager and the Environmental Stewardship staff responsible for compliance with DOE Order 458.1.

6.3. Collect and record direct measurement instrument background readings periodically. Identify and document background measurements on the survey form and maps with the survey unit number, "-BKG," and sequential background number (e.g. 1-BKG1, 1-BKG2, etc.). Collect background measurements on direct reading probes by pointing the probe into the air and away from any nearby surfaces.

6.4. Required Characterization Surveys include:

6.4.1. Surface scan surveys using a Ludlum 43-93/Thermo-Fisher RadEye (α / β) detector, listening for increased count rate areas.

6.4.2. 60 second scalar direct surveys using a Ludlum 43-93/Thermo-Fisher RadEye (α / β).

6.4.3. Smears (counted for α/β, tritium).

6.4.4. General Area External Radiation surveys using a Bicron μrem detector.

6.4.5. In-situ gamma spectral measurements for activation products in high suspect areas.

6.4.6. Concrete volumetric samples from high suspect areas. Volumetric samples will be analyzed for activation products and tritium.

6.5. QA survey measurements are required for MARSSIM Final Status Surveys. Duplicate measurements should be made at approximately 10 percent of the surveyed locations.

6.6. Scan percentages are specified in the survey unit and survey requirement tables for each survey unit (Section 9). For any areas of noticeably elevated count rate, a biased measurement (direct and smear) shall be collected and documented. When biased surveying is required, scan surveys should be used to decide locations of biased survey points, or the biased locations can be selected based on process knowledge. Denote biased surveys sequentially after the last systematic survey location. Biased measurement locations may include: high traffic areas such as room entrances, HVAC intakes and exhaust ducts, storage areas, areas of frequent personnel contact such as doors and door frames, horizontal surfaces such as lab counter tops and shelves, sinks, the openings to sink and floor drains; the tops of lights, beams, crane rails, structural beams, etc.

6.7. On the survey forms, denote surface material (e.g., “concrete,” “metal,” etc.), as well as locations of biased surveys.

6.8. Use provided survey maps, or create scaled maps as necessary, to document the survey locations and results.

6.9. Smear survey results are to be reported in the form consistent with the results from Health Physics Analysis Laboratory (HPAL). HPAL should be requested to report results as dpm/100cm^2 or dpm (not NDA). In consultation with HPAL, isotopic analysis can be performed on smears with high gross alpha/beta results if the radioisotope (or mixture) is unknown. Save all smears for possible future HPAL analysis.

6.10. Collect and maintain all characterization paperwork. Number each page of the survey unit packages using the format “XX of XX”. Survey Unit packages should include survey forms, maps, HPAL smear results, and HPAL isotopic analysis (if required). Provide all completed paperwork to the Project Manager and the Environmental Stewardship staff.

7.0 Surface Labeling Requirements

7.1. Denote survey unit location numbers on structure surfaces where measurements are obtained using non-permanent markers. Mark locations on using the survey unit designation plus the next sequential survey point location number. For example, for survey unit 16-5-2, location survey point number 5, mark the structure surface with the number 16-5-2-5.

7.2. The direct reading probe outline shall be drawn on the surface with a marker and a template to identify the exact surveyed location in the event a re-survey is necessary.

7.3. Denote on the survey map where the scan, direct, and smear surveys were performed. Scan area may be approximated by a highlighted/circled area in survey units that require less than 100% scanning. Record the general scan findings on the survey forms and/or maps.

8.0 Special Support and Safety Requirements

8.1. Upper walls and ceilings/roofs require access via ladders, scaffolding, man-lifts, etc.

8.2. Survey technicians shall be trained for elevated work.

8.3. Pest control may be required in and around all structures.

9.0 Sampling and Analysis Plans for Characterization Surveys

The following table outlines the requirements for the characterization surveys in TA-03-0016. Neutron measurements are not required.

Room	Smear surveys (β, tritium)	Direct (β)	Scan (β)	External Rad (γ)
Administrative Offices 100/101/102/103/104/105/106/108/110/112/112A/	~25 quasi-systematic grid per room (5 each wall and 5 on floor) plus 5 bias locations and 5 QA	Perform direct surveys next to each location smears were taken	< 10% surface area, biased locations	NA
Laboratories/Small Experimental Areas 114/114A/114B/114C/115/116/118/119/120/121/122/123/124/126/128/130/140/143/145/147/150/160/161/170 10/41/42/44/45/46/47/47A/48/	~25 quasi-systematic grid per room (5 each wall and 5 on floor) plus 10 bias locations and 10 QA	Perform direct surveys next to each location smears were taken	~75% surface area, biased locations	Highest General Area
Van De Graaf/Large Experimental Areas 40/50/62/64/65/66/67/69/70	~25 quasi-systematic grid per wall and floor plus 10 bias locations and 10 QA	Perform direct surveys next to each location smears were taken	~75% surface area, biased locations	Highest General Area
Exterior (Roof not required due to recent reroofing)	quasi-systematic 15 ft^2 grid 1 smear per 15 ft x 15 ft grid	Perform direct surveys next to each location smears were taken.	~75% surface area, biased locations	NA

APPENDIX B
Supplement to Characterization Plan for 3-16: MARSSIM Statistical Analysis, Output from VSP

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locationsto choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated number of samples	9
Number of samples adjusted for EMC	9
Number of samples with MARSSIM Overage	11
Number of samples on map [a]	0
Number of selected sample areas [b]	0
Specified sampling area [c]	5000.00 ft^2

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median (mean) value at the site is equal to or exceeds the threshold.The alternative hypothesis is that the median (mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information(e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usuallyless than if a non-parametric equation was used.

VSP offers many options to determine the locations at which measurements are made or samples are collected and subsequently measured. For this design, systematic grid point sampling was chosen. Locating the sample points systematically provides data that are all equidistant apart. This approach does not provide as much information about the spatial structure of the potential contamination as simple random sampling does. Knowledge of the spatial structure is useful for geostatistical analysis. However, it ensures that all portions of the site are equally represented. Statistical analyses of systematically collected data are valid if a random start to the grid is used.

Nuclides

The following table summarizes the analyzed nuclides.

Nuclide	**DCGL$_W$** *dpm/100cm^2*	**DCGL$_W$ = UBGR**	**LBGR** (*dpm/100cm^2)*	**Standard Deviation** (*dpm/100cm^2)*
Removable Alpha	20	AL-Removable α	Zero	MDA HPALα (6)
Removable Beta	1000	AL- Removable β (1000)	Zero	MDA HPALβ (11)
Removable H-3	10000	AL-Removable		MDA HPAL H-3 (35)
Total Alpha	100	AL-Total α	Median Ref. α (30)	Mean STD of Room α (15)
Total Beta	5000	AL-Total β	Median Ref. β (1537)	Mean STD of Room β (271)
IFB Alpha	260	Mean+2 STD Ref α	Median Ref. α (30)	Mean STD of Room α (15)
IFB Beta	2218	Mean+2 STD Ref β	Median Ref. β (1537)	Mean STD of Room β (271)

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For thissite, the null hypothesis is rejected in favor of the alternative one if the median (mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{S_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on (-,z) (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed inMARSSIM (EPA 2000, p. 5-33).

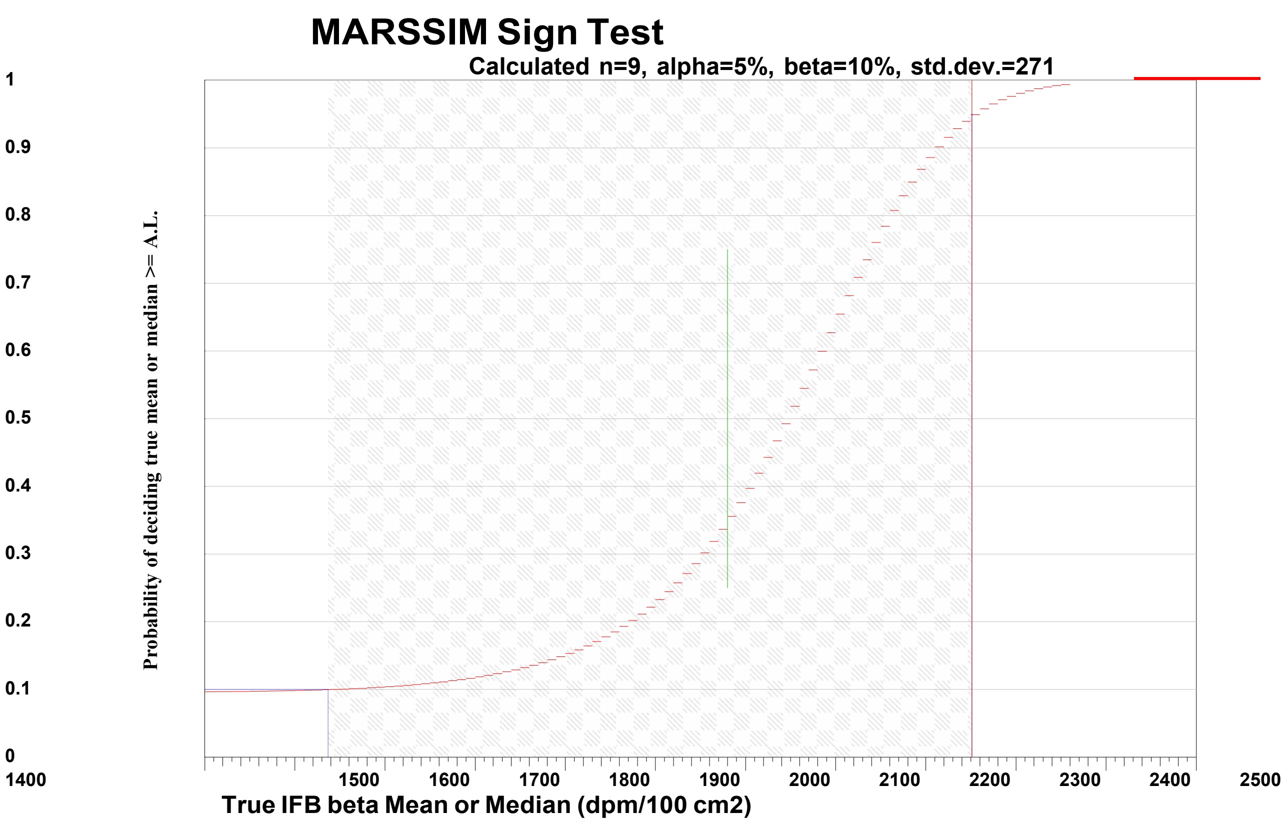
For each nuclide in the **Nuclides Analyzed by Study** table, the values of these inputs that result in the calculated number of sampling locations are:

Nuclide	n^a	n^b	n^c	Parameter					
				S_{total}	Δ	α	β	$Z_{1-\alpha}$ [d]	$Z_{1-\beta}$ [e]
Removable alpha	9	9	11	6	20	0.05	0.1	1.64485	1.28155
Removable beta	9	9	11	11	1000	0.05	0.1	1.64485	1.28155
Removable tritium	9	9	11	35	10000	0.05	0.1	1.64485	1.28155
Total alpha	9	9	11	15	70	0.05	0.1	1.64485	1.28155
Total beta	9	9	11	271	3463	0.05	0.1	1.64485	1.28155
IFB alpha	9	9	11	15	221	0.05	0.1	1.64485	1.28155
IFB beta	9	9	11	271	714	0.05	0.1	1.64485	1.28155

[a] The number of samples calculated by the formula.
[b] The number of samples increased by EMC calculations.
[c] The final number of samples increased by the MARSSIM Overage of 20%.
[d] This value is automatically calculated by VSP based upon the user defined value of α.
[e] This value is automatically calculated by VSP based upon the user defined value of β.

Performance
The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median (mean) valuesfor the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blueline is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputschange, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

   The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound ofgray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=2251		**α=5**		**α=10**		**α=15**	
		s=542	**s=271**	**s=542**	**s=271**	**s=542**	**s=271**
LBGR=90	**β=5**	126	38	100	30	84	26
	β=10	100	30	77	23	63	20
	β=15	84	26	63	20	51	16
LBGR=80	**β=5**	38	17	30	14	26	11
	β=10	30	14	23	11	20	9
	β=15	26	11	20	9	16	8
LBGR=70	**β=5**	22	15	17	11	15	10
	β=10	17	11	14	9	11	8
	β=15	15	10	11	8	9	6

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action levelα = Alpha (%), Probability of mistakenly concluding that μ < action levelAL = Action Level (Threshold)

Note: Values in table are not adjusted for EMC.

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